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# Development of cork-wings on certain trees. II.

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## ACER CAMPESTRE LINN.

Two kinds of Acer were examined, one, A. campestre, conspicuously winged till the stem is three or four years old, the other, *A. monspessulanum* Linn., much less, though the early part of its periderm formation is very similar to that of A. campestre. The development differs in both cases from that of Quercus, sufficiently, perhaps, to warrant a brief description.

Of Acer campestre, the young stem is six-angled, the periderm forms uniformly around this, by the cells of the first layer of primary rind becoming phellogen and developing centripetally[13] just as in case of Quercus. The breaking takes place along the six angles, the subsequently increased rapidity of growth under these fissures occurs, but with this difference, there is no line of distinction between the cells of the periderm formed previous to the splitting along the angles, and those of the wing formed by the renewed energy of the phellogen under these fissures. Instead of five, as in Quercus, there are six longitudinal bands growing faster than the remaining six; this continues till a furrow is formed along the top of each wing, making a similar shell-shaped appearance on the cross section as in Quercus. (See fig. 11.) Now very early in the development of the wing, the cells of the remaining six bands begin to grow and increase more rapidly than those of the former six, thus the central portion of each furrow is forced out until the edge of the wing is perfectly straight, in most instances no signs of the furrow being left. There is now no difference in the appearance of the cells of the entire wing. Toward the end of the summer, or the beginning of the fall growth, there are six strongly developed wings, the clefts between each two successive ones reaching quite down to the phellogen layer. The cells of the remaining epidermis have been so protected by this

[13] Centripetal is used here as by Sanio, in the sense that the newest tangential wall is nearest the center of the stem.

breaking in fissures and subsequent curling up, that not unfrequently the hairs from this tissue are seen along the smooth surface of the wing. This is shown in figure 11.*a*. As the autumn growth begins, several layers of narrow plate cells are formed entirely around the stem and it now takes its winter's rest. In the following spring, the manner of growth seems to vary. In most stems examined the process was quite similar to that of Quercus, the entire zone of phellogen cells developing rapidly till the protecting band of thicker walled plate cells breaks at the fissures and the new growth forces outward the last year's wings. This rarely, if ever, continued longer than till the third year; the growth of the three years' stems, as well as many of the two years', being as follows: As the girdle of plate cells breaks, the increased growth in circumference of the entire rind cells appears to take place most rapidly in sections under the fissures, or between the wings of the first or second year's growth. The periderm cells are formed more or less uniformly, but the foundations are laid for new wings between those already formed. In this way six more wings are formed, and not many seasons after this, the stem assumes the ordinary ridged and furrowed appearance which is no longer described as winged. Thus the transition from wings to ordinary furrowed periderm takes place. This method of transition is carried still further in

### Acer monspessulanum L.

The stems of the second and third year of this species can hardly be called winged, though the periderm growth of the first year corresponds to that of Acer campestre. That of the second year is similar to the third and fourth of the stems of the former. Little wings are formed between those of the first year so rapidly that a fissure occurs along the edges of these during their first year's growth; that is the second year of the stem. (See fig. 14.*f*.) The result of the repetition of this process is the formation of a periderm around the older branches with rather shallow and irregular furrows and by no means prominent ridges. This species thus may be considered a transition form between the regular cork wings of A. campestre and the comparatively smooth periderm on the young branches of the common maple.

### Liquidambar Styraciflua L.

The cork wings found on this tree have one striking peculiarity which renders them an exception to all other cases

examined. This is their eccentric or one-sided origin and growth. In this respect the species seems to stand quite alone. The specimens examined in the summer of 1887 were taken from trees of various ages and places of growth, all of them were under cultivation and all in the vicinity of Philadelphia, except those from the Arnold arboretum. In the summer of 1888, examples were obtained from trees of different ages growing wild near Woodbury, N. J. The results obtained from these, while confirming in most respects those obtained from the specimens of the previous year, were much more satisfactory, as the young tree in its early stages, up to those of fifteen years old, could be observed under natural conditions. The wings of the lateral branches appear always on the upper side, running along between the leaves, two, three and sometimes four in number. They generally stand at such an angle as to form troughs along the entire length of the branches. These are, of course, interrupted at the nodes by the leaf-petioles, but they slope gradually toward each other, so that the effect of a continuous trough is often produced. The main trunk is entirely surrounded by deep ridges and furrows along that part free from branches, and extending up perhaps half way through the crown of the tree. Above this a smooth periderm appears. A large number of specimens were studied, with a view of discovering the cause of the one-sided growth on the lateral branches.

The principal results of the anatomical study may be given in few words.

The first appearance of periderm formation occurs early in the year, but in most cases the youngest internodes of the year's growth are covered only by epidermis. The phellogen cells are in this case the second layer from the epidermis, so there is one layer of rind cells cut off, as de Bary says of a similar case, without wings, "for a very small bark." Lenticels are developed with this first periderm in considerable numbers. On the lateral branches at the time of the beginning of the cork wings, they are much larger, better developed and somewhat more numerous on the upper than on the under side of the stem. With this exception, the growth appears perfectly normal, a periderm of several layers is developed around the stem with lenticels connecting the rind cells with the outer air. After a time, along the upper side of the older internodes of this year's stems may be noticed an increase in the tissue around the lenticels. This may be easily identified by the naked eye as cork tissue from

its color, which is slightly reddish, and different from the rest of the surface. This is the first beginning of the wing; the tissue soon spreads from one lenticel to another until a ridge is seen extending along the upper surface of the internode. It is not possible to say that the wing always takes its rise from the lenticels, in this way, as instances of its origin between the lenticels, then spreading out so as to include them afterward, may have been overlooked. No such cork tissues were found entirely disconnected from the lenticels. Another fact pointing to the lenticellular origin of the wing is, there were several examples, where, for some lack of favorable conditions, the wing formation had stopped with the growth of cork immediately under the lenticels in such a manner that a number of these, lying in almost a straight line on the upper side of several successive internodes, were raised up from the surface for a distance of one or two millimeters. Usually there was only one ridge of cork at first; often, however, there were several smaller ones branching off, so that when developed a number of wings stood out at different angles.

The manner of growth of this tissue does not differ essentially from that of the previously described type. The phellogen layer in the vicinity of the lenticels becomes endued with unusual vitality; cells are cut off centripetally, and by this means the lenticel is raised up or away from the rind, a large number of cork cells intervening between it and the rind-cells. The opening of the lenticel now takes the place of the fissure made over the corner of the angular stem of Quercus and Acer above described. As the epidermis is raised up along the band, the longitudinal fissures already existing in the lenticels spread from one to the other until a continuous cleft is made along the whole internode. In this way are laid the foundations for two wings, which appear to be the normal number. In many cases, however, the development about each lenticel takes place in such a manner that instead of one connected line along the internode, several are formed; these often join each other at different points so that closed furrows are formed, the number of ridges, or wings, thus being increased to three, four, and even five; in the last case they nearly encircle the stem.

In those wings breaking along the openings of the lenticels, which have been described as normal, there occurs also another break which separates the wing from the remaining tissues. This is a break along the edges of the band of corky

tissue where it joins the regular periderm. This is shown in fig. 15, *b*. This breaking is prevented at first by the cells along these lines forming new walls at such angles as to form a fan-like spreading, large enough to accommodate the rapidly growing wing. The rapidity of growth, at first greater in the center of the wing, appears to gravitate toward the edges, and the break occurs. Both sections of the wing are now free to be shoved out by the rapidly growing phellogen. In the meantime the fissure in the middle, originating from the lenticel opening, increases till it reaches in many cases quite down to the primary rind. Toward the fall, about the middle of September in the examples studied, there are formed several layers of plate cells, extending around the whole stem. When growth is resumed in the following spring, the formation of cork is limited strictly to the phellogen under the wings; its rapid growth breaks the bands of plate cells and new layers are formed, pushing outward the growth of the previous year. As long as the vitality remains principally in the phellogen cells under the wings, this process is repeated each year; the breaking which takes place on renewed growth in the spring follows the lines already started, and the age of the stem may be estimated as surely by the number of broken bands of plate-cells along the edge of the wing, as by the number of woody rings on the other side of the cambium ring. The material for this study was very abundant, and a large number of specimens was examined; among them all was only one case in which the number of annual layers of cork did not agree with the number of woody layers of the stem. In this instance six rings of cork were found, where only three of wood could with certainty be detected. It is impossible to say, in this case, whether two rings of cork had been added each year, or whether the annual marking off of the wood had failed in the later years of growth, as the last ring of wood which was plainly marked off was about the width of both the other two. On many branches whose woody growth is not very rapid, these cork wings reach a comparatively enormous size, often measuring in depth twice and three times as much as the diameter of the remaining part of the stem. Some have been found fully three centimeters in depth, and one and a half centimeters is not an uncommon size. These large wings, when found on lateral branches, occur in most cases on stems which have closed their growth in length. Those stems whose growth in length is prolonged from year to year till

they form the main branches of the crown, begin, when young, to develop wings in the ordinary manner, and continue doing so for six or eight years. Then on the older internodes the development under the wings becomes less and less in amount; the ordinary periderm acc mmodates itself to the increasing size of the surface of the other parts of the stem, that under the wings apparently remaining stationary, until it is highly probable in many cases the growth of the wing entirely ceases and the phellogen of the entire circumference resumes its function of uniform growth, and the wings are slowly cracked off. However this may be, many of the larger stems appear to be covered with a nearly smooth periderm, and many others are nearly smooth at the place where they join the main trunk, while further on toward their extremities they are profusely covered with wings.

Now taking the growth of the main stem from its origin, a young tree, three years old, was cut off about one and a half feet from the ground. At this height the circumference was nearly covered with the cork wings, but by looking carefully it could be seen there was still a distinct longitudinal strip or band which was yet free from this growth except under the lenticels. This was more and more easily traced as one looked upward, until the last year's shoot which showed the typical one-sided formation. So with the oldest internodes of this year's growth; date, July 16. The whole length of this year's growth of main stem was forty-six centimeters; the lower thirteen centimeters had well-developed cork wings, above this none had yet appeared. Lateral branches growing out from this portion of the main stem were also supplied with wings on their older internodes. It is easy to see how the whole bole of the tree probably becomes covered with its ridged and furrowed periderm. In the tree just described, the longitudinal strip or band along which ran no regular wings was already supplied with corky tissue at the lenticels, raising these slightly from the surface. The phellogen cells of this tissue probably soon after the third or fourth year become endowed with special activity; the layer is extended from lenticel to lenticel, just as in the first year's growth, till at last connected ridges are formed, more or less irregular in their course, as the lenticels have no regular order of arrangement. These ridges assume, after a few years, an appearance entirely similar to those of the first year's growth. In fact, intermediate stages appeared already present where the lenticels appeared in cer-

tain stages, leading to the final result of covering the whole trunk of the tree. Ridges from a tree of fifteen years were broken off about four feet from the ground. The annual deposition of corky substance was seen here to diminish as the tree grows older, the later years' rings being much narrower than the earlier ones.

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## Botany at the University of Göttingen.

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The botanical department of the University at Göttingen, of which I have been requested to write a description, has never been particularly famous, yet has won and retained an excellent reputation in Germany for its good work and favorable advantages. Persons whose experience warrants the expression of an opinion, consider the arrangement of the laboratory to be equalled by few others in Europe, while the garden is notably well stocked and cared for. For the latter much credit is due Prof. Graf zu Solms Laubach, who for many years was director of the same and professor of systematic botany. In the spring of the present year he received almost simultaneous calls to the Universities at Strasburg and Berlin, accepted the former, and now occupies the chair of deBary.

There is a tacit division of the work here into the physiological and systematic departments, each presided over by different professors, and each with its own laboratory, branch library and lecture room.

The present director of the garden and professor of systematic botany is Dr. Peters, formerly a student and assistant with Nägeli. His work upon the genus Hieracium has secured him special notice. He was called to Göttingen from Munich, to take the place of Prof. Solms Laubach.

The garden, which is one of the sights of the not remarkably interesting old town, occupies, roughly estimated, five or six acres of ground, lying partly within and partly without the old "wall." The latter is no longer the defense for which it was planned and built some three or four hundred years ago, but has become a pleasant elevated promenade with grassy slopes and planted with a double row of fine old